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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : A61B 6/14, H01B 7/08, 13/00 — A1

(11) International Publication Number: WO 96/32064

(43) International Publication Date: 17 October 1996 (17.10.96)

(21) International Application Number: PCT/SE96/00420

(22) International Filing Date: 29 March 1996 (29.03.96)

(30) Priority Data:
9501332-2 10 April 1995 (10.04.95) SE

(71) Applicant (*for all designated States except US*): REGAM MEDICAL SYSTEMS INTERNATIONAL AB [SE/SE]; Regementsvägen 5, S-852 38 Sundsvall (SE).

(72) Inventor; and

(75) Inventor/Applicant (*for US only*): NELVIG, Per [SE/SE]; Granvägen 4, S-852 35 Sundsvall (SE).

(74) Agents: HEDBERG, Åke et al.; Dr. Ludwig Brann Patentbyrå AB, P.O. Box 1344, S-751 43 Uppsala (SE).

(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published

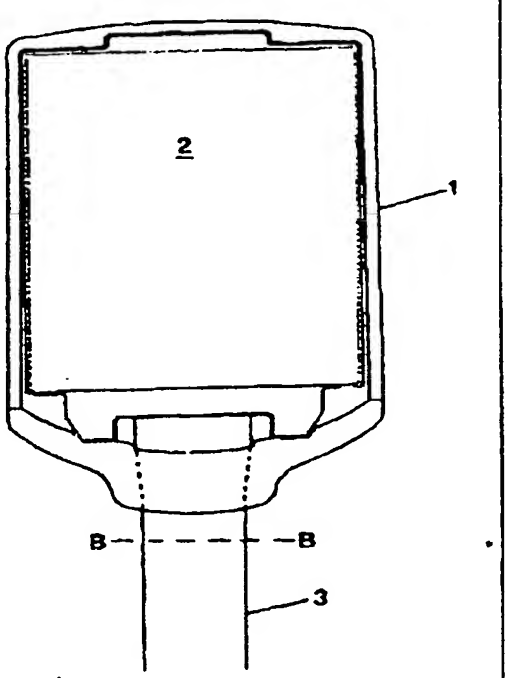
With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: ARRANGEMENT FOR INTRAORAL X-RAY CCD IMAGING ELEMENT

(57) Abstract

The present invention demonstrates thin flexible protected screened flat cable portion (3) for connection of an intraoral X-ray sensor (2) to its external electronic controller. According to the present invention, a flexible screened multi-wire flat cable portion (3) is produced, which can be passed through a very narrow gap between the teeth of the upper and lower jaws for producing "bitewing" images, as well as periapical images with or without the use of a bite-block, by means of the intraoral X-ray CCD sensor. The flexible screened flat multi-wire cable (3) permits sharp bending in different angles relative to the sensor capsule (1) with a very short bending radius and having an expected lifetime of several tens of thousands bendings with a small bending radius.



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Arrangement for intraoral X-ray CCD imaging element

Technical field

The present invention relates to intraoral registration of X-ray images of teeth and particularly to a flexible cable portion for connecting electric signals to and from a CCD imaging element for X-ray images of teeth.

Background of the invention

For many decades was basically used an analog imaging technique in dentistry by means of a film slice put into the patient's mouth and irradiate a smaller or larger portion of the oral cavity by X-rays to obtain images of teeth. Further developed systems for direct digital intraoral registration of X-ray images of teeth and surrounding tissue has been marketed since 1987. All systems available today are designed to utilize a similar basic concept in which an X-ray detector, usually a CCD-detector, is placed in the mouth behind a tooth that should be examined. A standard dental X-ray source is directed towards the tooth and detector. When the exposure button is pressed, the X-ray source emits X-ray radiation for a preset period. Depending on the X-ray absorption of the object (the tooth), a varying amount of radiation reaches the detector. The radiation that reaches the detector creates electrical signals that are proportional to the received dose at the different areas of the detector. By applying a series of clock pulses to the detector the image signals from the detector are possible read out. The only practical way to apply those clock pulses for reading the signals out is to use an electrical cable containing several conductors. Since the CCD detector is unable to store the image information for more than about 1 second, this readout has to be done with the detector still positioned in the mouth. For practical reasons, it is obvious that it is essential that the connecting cable is as thin and flexible as possible. On the other hand, a cable for driving and reading a CCD detector is required to contain a sufficient number of conductors to drive all the clock phases and to supply the different bias voltages needed for the operation of the CCD. A standard 3-phase CCD very often requires up to 12 wires. This

easily makes the cable bulky and impractical for some of the traditional intraoral projections.

One such projection is the so called "bitewing projection" where the film is placed behind the arches of teeth with the help of a thin film holder that keeps the film in place by letting the patient bite on the holder. The holder is sufficiently thin to allow a gap, approximately less than 2 mm, between the occlusal surfaces of the teeth. The purpose of the projection is to enable visualization of the crowns and the marginal bone of both the upper jaw and the lower jaw simultaneously. Such images are used for both caries and periodontal lesion detection.

With an electronic sensor, the sensitive area is from practical reasons, usually smaller than a 3 x 4 cm analog film. This smaller size results in a smaller tolerance for display of the marginal bone in bitewing images. A thick cable results in a wider gap between the teeth, resulting in an even smaller tolerance. To use a sensor with a sensitive area of 2 x 3 cm and a 5 mm thick cable for "bitewings" is considered to be impossible by many users.

Other problems with conventional cables with many conductors is a lacking flexibility. If the cable is attached to for instance the short edge of the sensor the ideal angle of the cable in relation to the sensor varies from application to application. When ordinary periapical projections are supposed to be exposed, it is favorable to let the cable run in a slot in the bite-block used for positioning of the sensor. This is easily achieved if the cable is attached to the short end of the package at an angle perpendicular to the sensitive area. On the other hand, during root-canal therapy, a bite block and an angular cable arrangement is not practical since it would interfere with the rubber dam and the root-canal instruments. In this case, a direction of the cable not interfering with the instruments is to prefer. To design a conventional cable, with a sufficient number of conductors, that allows nearly 90 degrees flexure, repeatedly and

very close to the sensor package, is difficult and expensive. It is also expensive to produce and a possible cause of failure.

Flat cables have been frequently used in industrial high volume products mainly for two reasons: They provide great flexibility and can normally be bent with a fairly short radius. Therefore they are often used in electromechanical products where, moving electronic parts has to be connected to stationary electronics. Examples are printers and removable or fixed disk drives.

Flat cables also provide very efficient production methods. Since they have a very precise layout, the spacing between the conductors is well known, whereby it will be possible to connect several conductors in one single production operation, either automatically or manually while a conventional cable requires one or more operations for each conductor.

Still there is a lack of a suitable type of cable for interconnecting a CCD sensor to its control electronics.

Short description of the invention:

The present invention discloses a particular thin flexible protected screened flat cable portion for connection of an intraoral X-ray sensor to its external electronic controller.

A first object, according to a method of the present invention, is to produce a flexible screened multi-wire flat cable portion and according to the present invention a flexible screened multi-wire flat cable portion device which can be passed through a very narrow gap between the teeth of the upper and lower jaws for producing "bitewing" images, as well as periapical images with or without the use of a bite-block, by means of an intraoral X-ray CCD sensor, this flexible screened flat multi-wire cable permitting sharp bending in different angles relative to the sensor with a very short bending radius and having a very long lifetime for bendings with a small bending radius.

A second object introduces, according to a method and device of the present invention, a sliding film between the screened flat multi-wire cable and an outer protecting mantle to further increase the flexibility of the flexible screened multi-wire flat cable portion.

A third object of the present invention is to use the flexible screened flat multi-wire cable portion in a system including a CCD sensor.

Furter embodiments are additionally defined by a number of different dependent claims.

Short description of the drawings

The invention will be described by preferred embodiments to be contemplated with reference to the accompanying drawings wherein like reference numerals are used throughout to designate like parts. In the drawings:

Fig. 1 is a horisontal plane view cut through a image sensor capsule utilizing the flat cable portion according to the present invention;

Fig. 2 is a horisontal plane view cut through a image sensor capsule of Fig. 1 with the image sensor protective case removed;

Fig. 3 is an enlarged portion of Fig. 2;

Fig. 4 is an elevated side view along a cut A - A of the image sensor and its flat cable sensor of Fig. 2; and

Fig. 5 is a cross section along a cut B - B in Fig. 1 of the flat cable portion according the present invention.

A preferred embodiment:

In a preferred embodiment, for use for instance with a commercially available CCD sensor capsule (Regam Medical Systems AB, Sundsvall, Sweden), the conductors in a cable 3 are made of metal foil, e.g. copper, laminated between very thin (preferably < 0.2 mm) layers of high quality plastic, for example polyimide forming a flat conductor cable 13. In Figs. 1 and 2 are demonstrated a cross section of a CCD image sensor capsule and its connecting cable 3. The layout of the conductors in this flat cable 13 is manufactured in a way similar to the production of printed circuit boards. Since, in this application, a large area, 3-phase CCD sensor 2 is supposed to be driven through the flat conductor cable 13, a sequence of high frequency (appr. 1 MHz) pulses will be applied, in the preferred embodiment, to up to seven of the conductors at a second end of this cable portion which is, for instance, about 40 cm long. At a first end of the cable portion, the CCD sensor 2 represents a relatively high capacitive load. This means that electrical current pulses in the conductors can reach levels where a significant amount of radio frequency radiation will be emitted. To prevent this radiation to escape to the environment an electrical screen is necessary. In a preferred embodiment according to Fig. 5, the screen 10 is spun into two crosswise layers onto the plastic-metal-plastic laminate constituting the flat conductor cable 13. The screen 10 could be manufactured by rotating the flat cable portion, held under tension by two jaw chucks that can be synchroneously rotated, simultaneously feeding a thin electrically conductive wire onto the cable in such a way that two crosswire layers of this wire are obtained.

In an alternative embodiment, the screen 10 could be provided by spinning a single, overlapping layer of thin metal foil tape with a method similar to what is described above.

In another embodiment strips of thin metal foil placed on each side of the flat cable could provide the screening function. In this case it is important that a thin layer of friction reducing

material is placed between each of the screening strips and the cable to maintain high flexibility.

An outer polyurethane mantle 14 is pulled over the cable/screen assembly to prevent the cable from moderate bite-forces when used for "bitewing" imaging, and to provide an electrical insulation besides protecting the cable from saliva and disinfectant solutions. In the preferred embodiment, the high quality plastic carrier is approximately 8 mm wide and carries 14 conductors and the spun screen 10 is covered with a sliding film 12, for instance, of PTFE (polytetraflourethylene) or the like, between the screened flat cable 13 and the outer thin mantle 14 of polyurethane to increase the flexibility of the resulting insulated, protected cable 3.

At a first end the flat cable is connected to a CCD sensor and at a second end it is connected to a conventional cable that leads to an electronics box that controls the CCD sensor. The conventional cable is screened, and may be several meters of length. The transition from the flat cable to the conventional cable is conveniently performed, for example, by means of standard connector plugs. Therefore, the electronics box can be disposed several meters away from working area close to the patient.

At some place in the housing of the CCD image package there has to be some kind of a feed-through for the cable 3, for instance at one of the edges of the short sides or at the back of the package. In either case, the feed-through must provide the following functions:

1) it should be designed in such a way that moisture is prevented from entering into the package,

2) it should provide a good fixation of the cable.

In the preferred embodiment the feed-through is designed as an end-piece 4, that also serves as the final seal of the package.

In an alternative embodiment, this end-piece 4 is composed of two halves that are put together around the cable. The two halves can be held together using an adhesive resin or cured resin and possibly reinforced by small dimension screws and nuts which is common in similar devices.

In yet another embodiment, this end-piece 4 could be formed around the cable by injection molding.

In the preferred embodiment the fixation of the cable to the end-piece 4 is provided by first laminating a thin reinforcement of fibreglass laminate to the cable. During final assembly this reinforcement is fitted into a slot of the end-piece 4 and the passage through the end-piece is sealed by the use of, for instance, adhesive resin.

In another embodiment the polyimide base of the cable could be locally widened and perforated at the passage through the end-piece to allow attachment to the end piece through mechanical locking. It should also be emphasised that the passage through the package could be arranged in similar manners at any part of the package.

At the first end where cable is attached to the CCD image sensor 2 it passes through the end piece 4 of the sensor package. The mantle is attached to the through-hole of the end-piece by combination of adhesive resin and a wedge action of a 0.3 mm thick fiberglass reinforcement, that is laminated to the first end of high quality plastic flat cable 3. When the cable 3 is mounted to the end piece 4, the whole length of the cable 3 is pulled through the hole in the end piece until the fiberglass reinforcement edge at the first end fits into a slot in the end-piece 4. Before the reinforcement is pressed into the slot, a suitable amount of adhesive resin is applied to the parts. In this way, two separate moisture barriers between the environment and the interior of the package are created, one barrier between the mantle 14 and the end-piece 4 through wedge action of a tab

of the fiberglass reinforcement that presses the mantle against the walls of the through-hole and another barrier between the fiberglass reinforced high quality plastic and the end-piece 4 by the use of adhesive resin.

A flexible printed circuit board, PCB, being integrated into the interior of the sensor package is about 23 * 50 mm as demonstrated in Fig. 4 in an illustrative embodiment. This PCB is used for electronic circuitry components such as drivers for the CCD clock phases and triggering circuitry detector amplifiers. The reason for including such circuitry into the package is that radio frequency interference emissions can be reduced. This flexible PCB is in a preferred embodiment folded into a double sandwich 6 before final assembly of the sensor, cable and package. A sensor carrier 5 is soldered to the flexible folded board 6 which then is integral with the cable portion 3 of a preferred embodiment. The CCD image element 2 is than put onto the carrier 5 and connected to to the circuitry of the flexible board 6, which is integral with the flat cable 13 in the mantle 14 och the connecting cable 3. The housing is completed by adding a case portion 1 to the end-piece 4 thereby sealed enclosing the image sensor into a capsule. Such an embodiment makes the connection to the sensor itself very straightforward.

Further objects, features and a more complete understanding of the present invention, which may admit to a number of possible variations, will be apparent from the following detailed description which, considered in conjunction with the attached drawings, represents the preferred embodiments of this invention and should be considered in an illustative and not in a limiting sense as follows.

CLAIMS

1. A method of producing a flat cable portion having first and second electric connection ends for electrically connecting an intraoral X-ray CCD sensor to an external electronics device to thereby obtain also a possiblity of "bitewing" imaging, as well as periapical images with or without the use of an bite block, by means of a CCD sensor, **characterized by** the steps of:

laminating several thin strips of metal foil between very thin layers of very flexible high quality plastic, thereby forming a thin flexible plastic-metal-plastic laminate (13);

screening the several laminated metal foil strips by means of an electrically conducting material (10);

arranging an outer thin mantle (14) over said thin screened flexible flat cable to obtain an insulated, protected, flexible flat cable portion (3);

forming a flexible printed board circuit (6) integral with said flexible flat cable portion (3) at a first end forming a printed board circuit for connection to said CCD sensor.

2. The metod according to claim 1, **characterized by** an additional step of spinning a thin wire into at least two thin crosswise layers onto said flexible plastic-metal-plastic laminate (13) to form a thin flexible screened laminate;

3. The metod according to claim 1, **characterized by**

forming a reinforcement at the lead-through of said flexible flat cable portion to achive an extra moisture barrier at the insertion point of the first end of said flexible flat cable into a capsule (1) containing the CCD sensor.

4. The metod according to claim 1, **characterized by** inserting a sliding film (12) between said flexible screened laminate (13, 10) and said outer thin mantle (14) to increase the flexibility of the cable and obtaining a flexible screened and protected long-lasting cable able to present a small bending radius and which cable portion will stand repeated sharp bending.

5. The metod according to claim 1, **characterized by** using polyimide as said high quality plastic.

6. The metod according to claim 1, **characterized by** using polyurethane for said mantle (14).

7. The metod according to claim 1, **characterized by** using a thin metal or a metal alloy tape as said electrically conducting material for spinning said screen (10).

8. A flat cable device having first and second electric connection ends for electrically connecting an intraoral X-ray CCD sensor to an external electronics device to thereby obtain also a possiblity of "bitewing" imaging, as well as periapical images with or without the use of an bite block, by means of a CCD sensor, **characterized by** several thin strips of metal foil laminated between very thin layers of very flexible high quality plastic, thereby forming a thin flexible plastic-metal-plastic laminate (13), whereby said several laminated metal foil strips are screened by an electrically conducting material spun into at least two thin crosswise layers (10) onto said flexible plastic-metal-plastic laminate forming a thin flexible screened flat cable (3), and an outer thin mantle (14) arranged over said thin flexible screened flat cable to obtain an insulated, protected, flexible flat cable portion and a flexible printed board circuit (6) integral with said flexible flat cable portion (3) at a first end, said printed board circuit connecting to said CCD sensor (2).

9. The device according to claim 8, **characterized in** further having a wedge acting reinforcement at the first electric connection end of said flexible flat cable portion (3) to achive an extra moisture barrier for the insertion of the first end of said flat cable portion (3) into a capsule (1) containing the CCD sensor element (2).

10. The device according to claim 8, **characterized by** a sliding film (10) inserted between said flexible screened laminate (13, 10) and said outer thin mantle (14) to increase the flexibility of the resulting insulated, protected, flexible flat cable portion (3), thereby obtaining a flexible screened and protected long-lasting cable able to present a small bending radius and which cable portion (3) will stand repeated sharp bending.

11. The device according to claim 8, **characterized in** that the high quality plastic is a polyimide.

12. The device according to claim 8, **characterized in** that said mantle (14) is made out of polyurethane.

13. The device according to claim 8, **characterized by** using a thin metal or a metal alloy tape as the electrically conducting material for spinning said screen layer (10).

14. System for electrically connecting an intraoral X-ray CCD sensor to an external electronics device to thereby obtain a possiblity of "bitewing" imaging using a CCD sensor, **characterized in** that a first electric connection end of a flat cable portion (3) is integral with a flexible printed circuit board (6), whereby said flexible flat cable portion (3), through a corresponding through-hole of a capsule (1) for housing said printed circuit board (6) and said CCD sensor (2), is put into a position where the wedge acting reinforcement locks in said though-hole which at the same time acts as a moisture barrier.

15. System according to claim 14, characterized in that said second electric connection end of said flexible flat cable portion (3) is connected to an electronic device, directly or via an additional multi-wire cable.

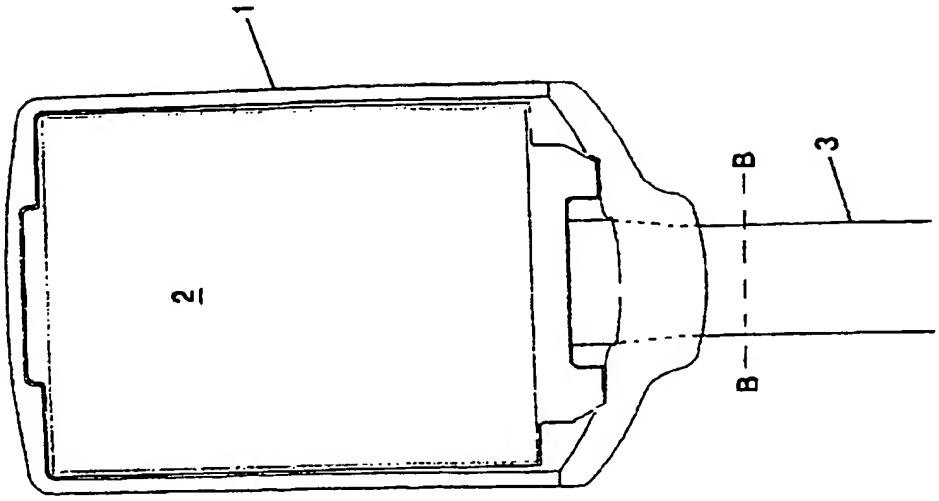

Fig. 1

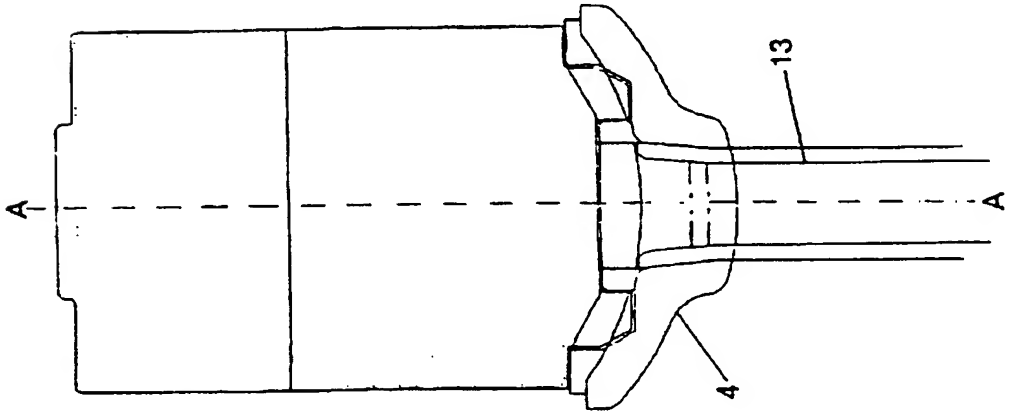

Fig. 2

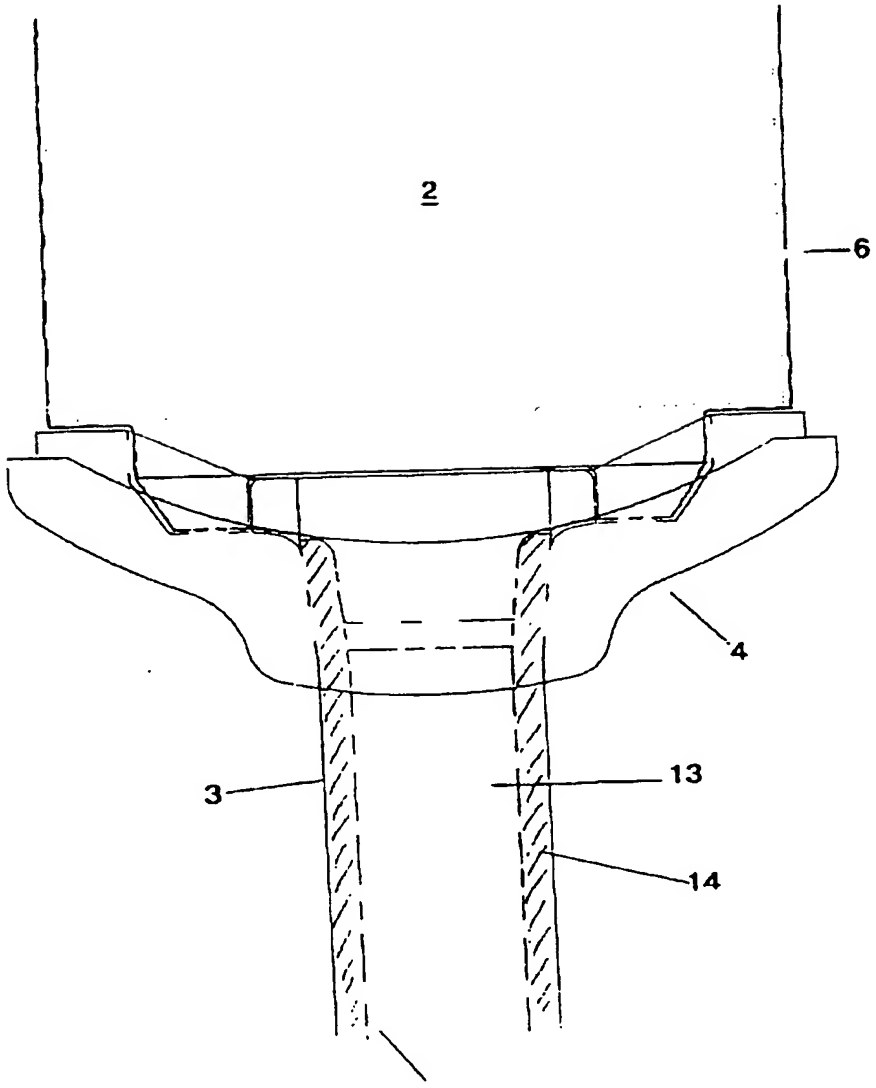

Fig. 3

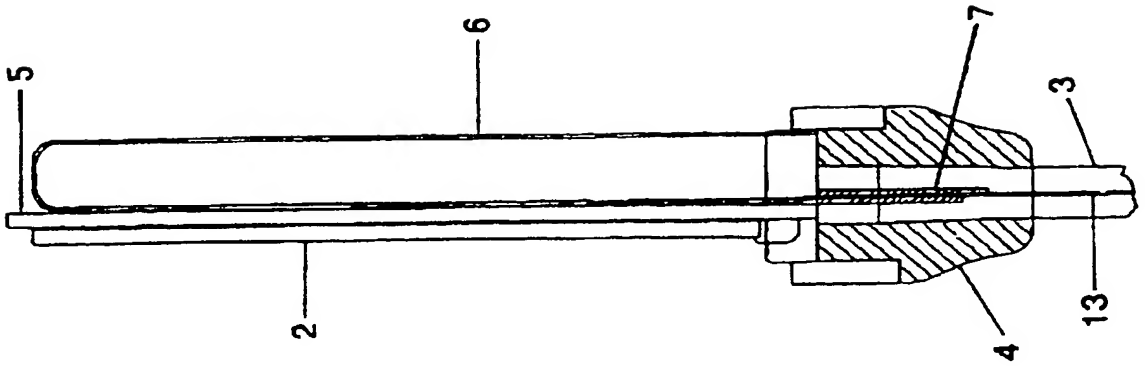

Fig. 4

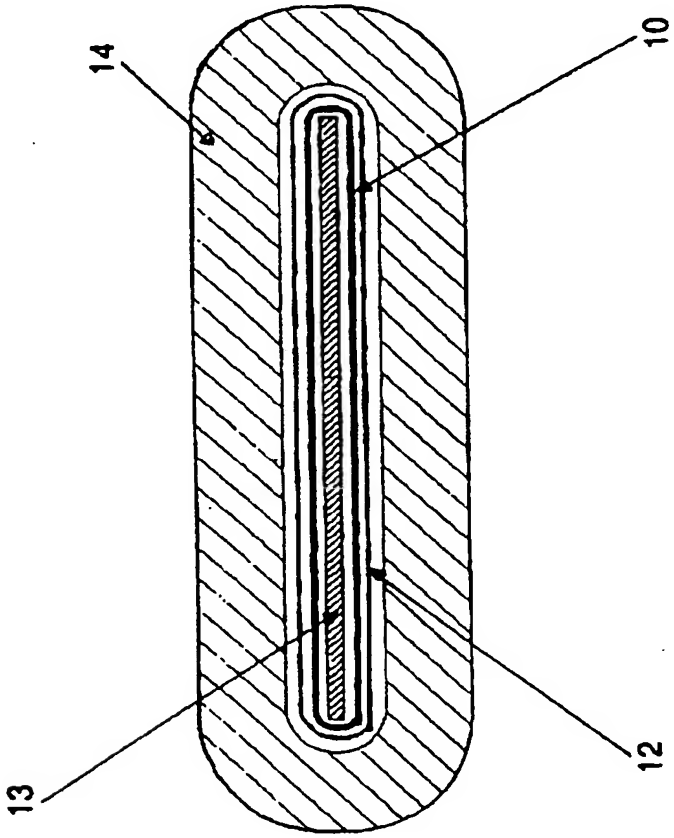

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 96/00420

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: A61B 6/14, H01B 7/08, H01B 13/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: A61B, H01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A		14-15
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A		14-15
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A	EP 0447946 A1 (ERNST & ENGBRING GMBH), 25 Sept 1991 (25.09.91), abstract	4
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

31/07/96

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